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WO 96/02094 A1 WO 94/28684 A1 JP 090130862 A

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(54) Abstract Title
Aircraft communication arrangement

(57) A communication arrangement enables aircraft passengers to use their normal mobile phones for communication with ground-based parties. A mobile phone microcell is established on the aircraft by means of antennas 35 mounted at locations around the aircraft and connected to a base transceiver station BTS 33 of a base station subsystem BSS 31 on the aircraft. Communications between the BTS 31 and ground are established by means of a bearer system comprising a transceiver 36 on the aircraft and ground based transceivers 39 connected to a ground switching centre GSC 40, which is coupled via an aeronautical gateway mobile switching centre GMSC 70 to a conventional mobile phone system 50, a PSTN and an ISDN. The on-board BSS 31 and the ground based mobile system 50 may be GSM systems. The on-board BSS 31 may supp rt a plurality of different mobile systems. The bearer system 36, 39 may be a Terrestrial Flight Telecommunications Service (TFTS) system, or a SATCOM, IRIDIUM or NATS system. The on-board base station controller BSC 34 reduces the power level of the on-board mobiles to the minimum useable level, in rder to reduce interference to aircraft and ground equipment. The BSC 34 may also be able to shut off mobile ph nes inside the aircraft if power level exceeds a given value.

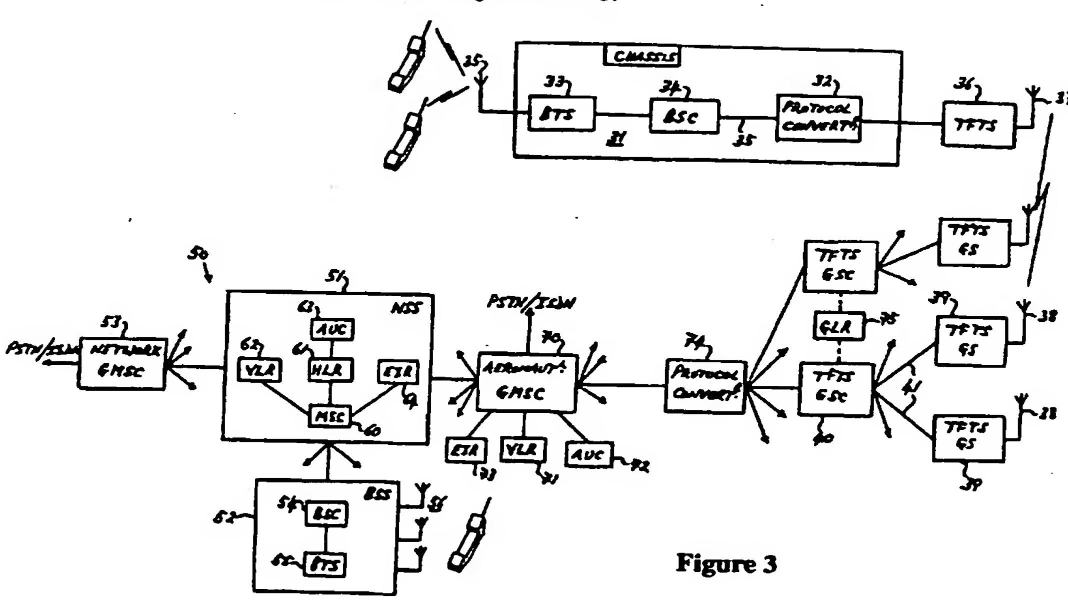

Figure 3

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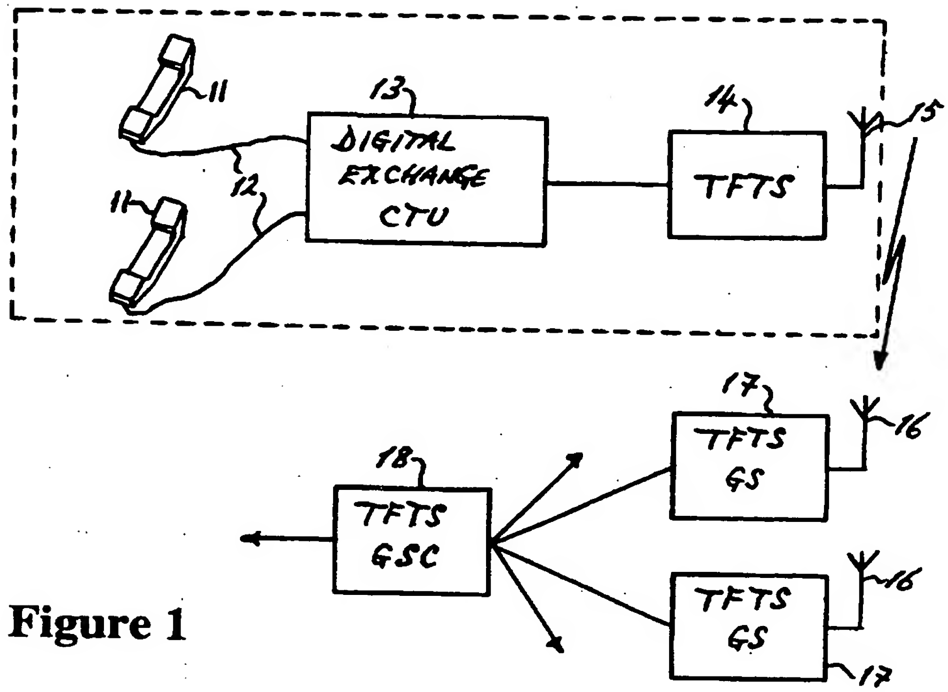


Figure 1

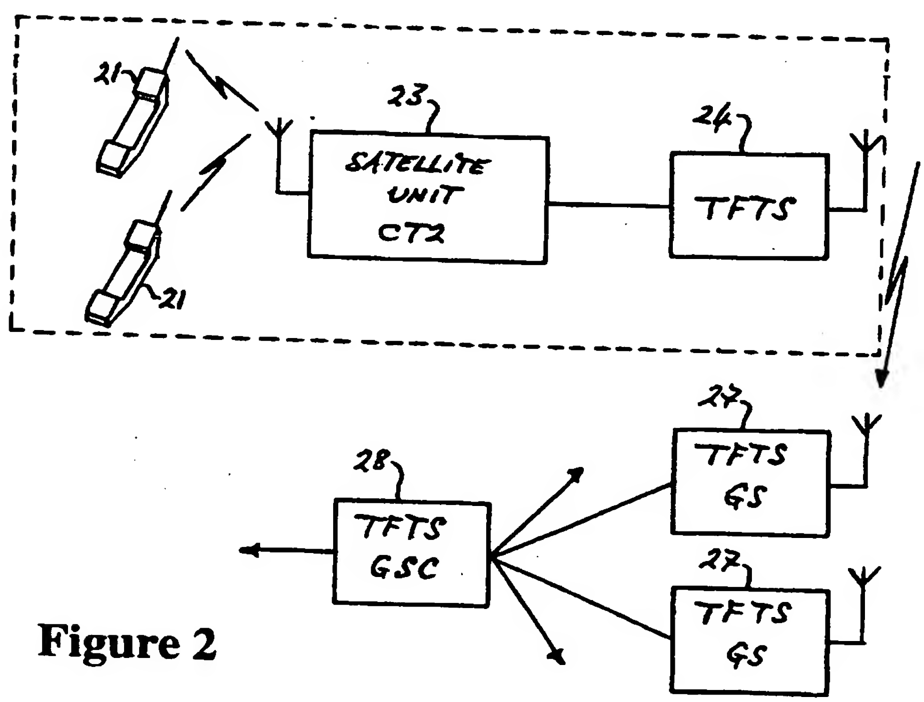
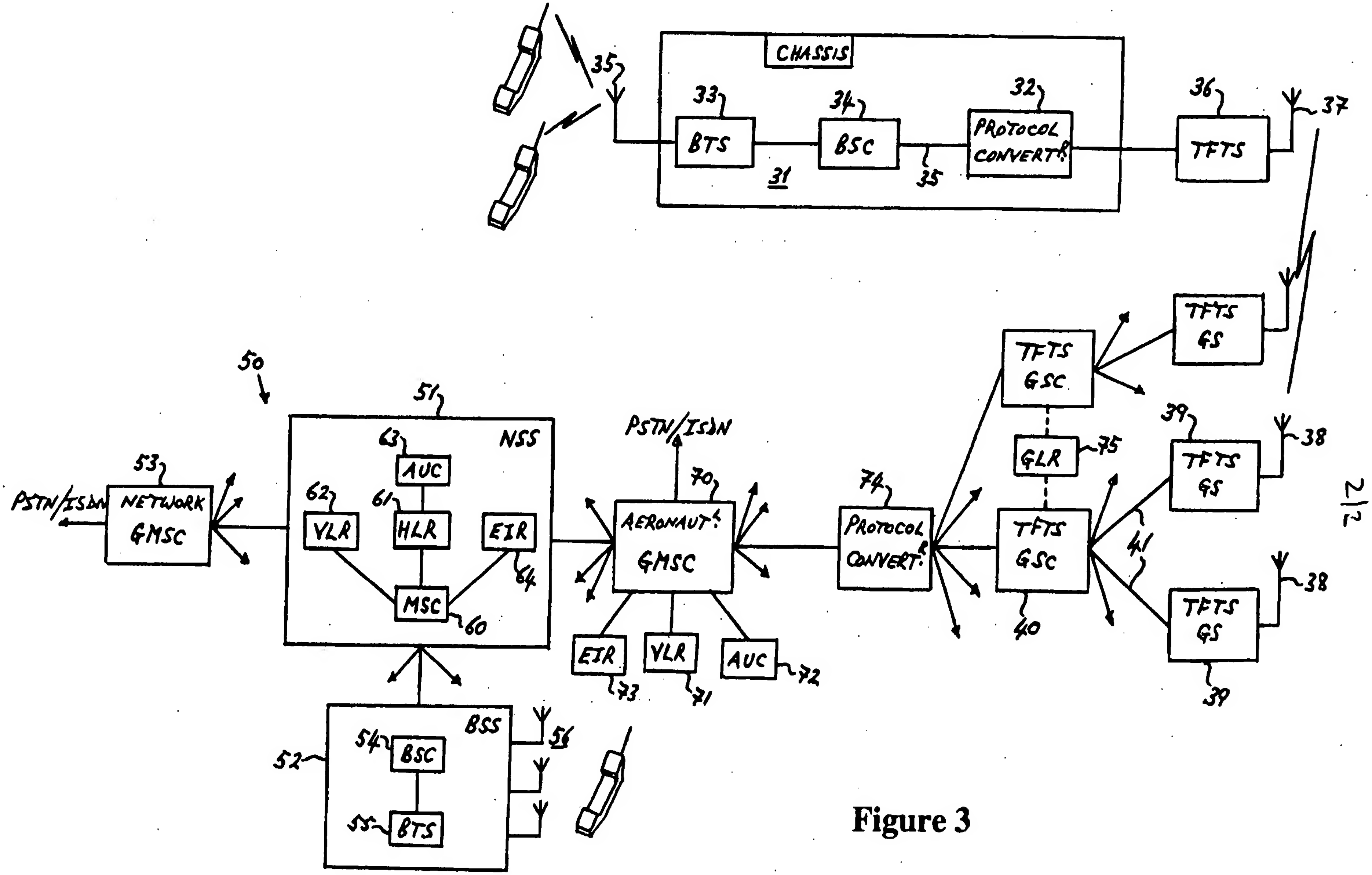


Figure 2



CHASSIS
35
33
BTS
34
BSC
32
PROTOCOL CONVERT^R
31
35
36
TFTS
37
TFTS GS
TFTS GSC
GLR
75
39
TFTS GS
38
TFTS GSC
41
40
TFTS GS
38
39
50
51
NSS
63
AUC
62
VLR
61
HLR
EIR
64
MSC
60
53
NETWORK GMSC
PSTN/ISDN
PSTN/ISDN
70
AERONAUT^L GMSC
EIR
73
VLR
71
AUC
72
74
PROTOCOL CONVERT^R
52
BSS
54
BSC
55
BTS
56

Figure 3

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COMMUNICATIONS ARRANGEMENT

The invention relates to a communications arrangement enabling the occupants of an aircraft to communicate with other parties over a radio link.

Arrangements are already known for establishing telephone communication between a passenger on an aircraft and a ground-based party, two such arrangements being a hard-wired system and a cordless system, outlines of which are shown in Figures 1 and 2, respectively.

The hard-wired system comprises a number of phones 11 connected by respective electric cables 12 to a central digital exchange 13 (a CTU) on board the aircraft. The exchange sets up a communications link to ground through a bearer 14, such as a TFTS (Terrestrial Flight Telecommunications Service) unit, which co-operates via antennas 15, 16 with a series of, e.g. TFTS, ground stations (GS) 17 forming a network on the ground. The network is large enough to cover a suitably broad area for the capturing of signals from an overflying aircraft and in practice may comprise GS's along a flight path and also at individual airports. A TFTS ground switching centre (GSC) 18, of which there may be more than one (see Figure 3), controls the operating parameters of the GS's, e.g. their frequency of operation and transmission power, and also takes note of which TFTS GS is being used at any particular time by a particular aircraft and manages the establishment and clearing of telephone calls. Communications are routed via the TFTS GSC 18 to a ground-based communications network (not shown) such as a PSTN (Public Switched Telephone Network) or ISDN (Integrated Services Digital Network), these networks terminating in the called party once a link has been established.

The cordless system (Figure 2) makes use of a number of cordless phones 21 communicating with a central onboard satellite unit 23 (e.g. of the type known as CT2), this unit as in the hard-wired case being connected to a radio bearer 24, such as a TFTS transceiver, and thence via a radio link to corresponding ground-based equipment - TFTS transceiver stations 27 and ground switching centre 28 - again ultimately terminating in the called party once a ground-based link has been completed through the ISDN or PSTN network.

Both systems have a number of drawbacks: firstly, the airline operator concerned has to provide dedicated phones inside the aircraft, which clearly incurs a not insignificant cost (bearing in mind also the possibility of theft by unscrupulous passengers); secondly, and more importantly, a communications link can only be established in one direction, namely from the onboard passenger down toward ground. It has not up till now been practicable to establish a link in the reverse direction. There are a number of reasons for this, the most significant being the small window of opportunity for contacting a passenger successfully on a short flight. A third drawback is the fact that the user of the system is forced to use a strange instrument which he, in the first place, might not be familiar with and, in the second place, might be wary of using from a hygiene point of view.

In accordance with a first aspect of the present invention there is provided an aircraft communications apparatus for establishing a communications link between a party on an aircraft and a party external to the aircraft, comprising a means for defining

a radio-frequency microcell within the aircraft, the cell-defining means being functional, in use, in co-operation with a mobile station employed by said party on the aircraft.

Advantageously, the cell-defining means may be configured to operate under the same format as a ground mobile network system in association with which the mobile station is configured to operate.

The cell-defining means may comprise a base station subsystem and one or more antennas connected to the base station subsystem. The antennas may be distributed around an interior space of the aircraft.

The apparatus may include a bearer transceiver means connected to the base station subsystem for the establishing of said link, the two being interconnected by a protocol-conversion means.

The base station subsystem may comprise a base station controller and a base station transceiver. The base station subsystem may be operable at more than one broadcast frequency.

The apparatus may comprise also a power monitor connected to the defining means for the monitoring of the level of power radiated by the mobile stations and for the switching off of the mobile stations when the level exceeds a given value.

An aeronautical gateway switching device may be provided for the interfacing of signals from the cell-defining means with a mobile communications network and/or a public switched telephone network and/or an integrated services digital network. The aeronautical gateway switching device may interface said signals by way of a ground-

based bearer apparatus which, in use, communicates with the on-board bearer transceiver means.

A further protocol conversion means may be provided for the interfacing of the gateway switching device with the ground-based bearer apparatus.

In accordance with a second aspect of the present invention there is provided a communications arrangement for the establishing of a communications link between an occupant of an aircraft and another party, comprising:

- in an aircraft, a microcell-defining means configured in accordance with a given mobile-communications format for co-operation with one or more onboard mobile terminals likewise configured to operate under the given format, and a first bearer means connected to the cell-defining means for establishing a communications link with ground, and

- on the ground, a second bearer means for communicating with the first bearer means, a mobile-communications network configured according to the given format, and a gateway switching device connected to interface the second bearer means with the mobile-communications network and with a public switched telephone network and/or an integrated services digital network.

The cell-defining means and the mobile communications network may operate under the GSM format and the bearer system may be one of a group comprising TFTS, SATCOM, NATS and IRIDIUM.

An embodiment of the invention will now be described with the aid of the drawings, of which:

Figure 1 is a schematic block diagram of a hard-wired communications arrangement employed in aircraft for air-to-ground communication;

Figure 2 is a schematic block diagram of a cordless-phone communications arrangement employed in aircraft for air-to-ground communication, and

Figure 3 is a block schematic diagram of a communications arrangement according to the present invention and employing an on-board GSM microcell in conjunction with a TFTS bearer.

Turning to Figure 3 now, there is introduced into the aircraft an apparatus comprising a GSM (Global System for Mobile communications) base station subsystem (BSS) 31 and a protocol converter 32. The BSS 31 consists, conventionally, of a base transceiver station (BTS) 33 and a base station controller (BSC) 34. The BTS 33 feeds one or more antennas 35 which are mounted at suitable locations around the aircraft interior, thereby defining a microcell. The apparatus is advantageously realised as an integral unit comprising a chassis, a power supply unit (PSU) and the protocol converter, though other mechanical arrangements are possible. Readily available BTS and BSC equipment may be employed in these positions, but may well have to be modified to withstand the aircraft environment, which is more hostile than the more usual ground-based environment, for example in terms of the vibration to which it may be exposed during flight. In addition, the PSU part of the apparatus will have to be able to provide the normal BTS and BSC voltage supplies from the conventionally differing aircraft supplies.

The protocol converter 32 is connected in turn to a bearer unit 36, typically TFTS, which radiates via an antenna 37 communication signals at an appropriate frequency, e.g. 1800 MHz, to ground apparatus which will be described shortly. The converter 32 performs the function of changing the format of the signals leaving/entering the BSC on line 35 into a format which the TFTS can accept. More specifically, the interface between the BSC 34 and the aeronautical GMSC 70 is a so-called "A" interface, while that between the converter and the TFTS unit is an interface conforming to ETSI ETS 300326 and ETS 300752. The protocol converter makes the necessary adjustments to the messages to allow transmission through the TFTS bearer. (Since the interface between the phones and the BTS is the usual Um interface, while that between the BTS and the BSC is the conventional Abis interface, no special protocol converter is required in those positions).

Forming part of the ground-based equipment, and serving to communicate with the TFTS unit 36 via their own antennas 38, are a number of TFTS ground stations (GS) 39 which form, along with a TFTS ground switching centre (GSC) 40, a TFTS network as described earlier in connection with the known air-to-ground communications arrangements.

The communication signals passing through the TFTS GSC 40 are routed via an equipment (not shown) providing some of the functionality of a GSM MSC through to a conventional GSM network 50 comprising a number of network subsystems NSS 51 and a number of base station subsystems BSS 52. The network subsystems 51 connect

to a common gateway mobile switching centre 53 which links up with the PSTN (Public Switched Telephone) or ISDN (Integrated Services Digital) networks.

The BSS's 52, of which only one is shown, comprise the same equipment functionality as the BSS 31 in the aircraft, namely a BSC 54 and a BTS 55 terminating in a number of antennas 56. In practice there may be more than one BTS served by the BSC 54, each feeding more than one antenna 56. The area covered by a single BTS defines a "cell" and the area covered by a number of BTS's under the control of the BSC 54 defines a "location area" (LA).

Each NSS 51 may be taken to comprise a mobile switching centre (MSC) 60, including the functionality of a home location register (HLR) 61 and a visitor location register (VLR) 62, an authentication centre (AUC) 63 and an equipment identity register (EIR) 64. The function of these is as described in the GSM standards.

Forming a link between the existing GSM network 51, 52, 53 and the TFTS network 39, 40 is an aeronautical gateway mobile switching centre (GMSC) 70 similar to the network GMSC 53. The GMSC 70 is associated with its own VLR 71, authentication centre (AUC) 72 and equipment identity register (EIR) 73 and is connected to the PSTN/ISDN networks. In addition, since the GMSC employs the same "A" interface as that of the on-board BSC 34, a further protocol converter 74 similar to the on-board converter 32 is included to interface the GMSC 70 to the TFTS GSC 40.

The operation of this embodiment of the communications system according to the invention will now be described.

Although the system, as described, will support telephone calls initiated both from the aircraft and from the ground, for the purpose of illustration it is first of all assumed that a fixed ground-based caller, F, wishes to contact a mobile-phone carrying passenger, M, on board the aircraft containing the BSS equipment 31. It should first be appreciated that M is assumed to be "registered" with a particular cellular operator (e.g. Cellnet or Vodaphone in the UK) and to have the "international roaming" facility enabled, and his details are contained in a particular "home" location register (HLR) associated with a particular "home" MSC, e.g. the HLR 61 and MSC 60 in Figure 3. The HLR will contain all the permanent and semi-permanent data peculiar to M, including his service profile (which services he has subscribed to), his international mobile subscriber identity (IMSI), which is his unique identifier on the network, his mobile station roaming number (MSRN), which defines his current location, and his activity status, which includes a log of his calls, their duration and cost. In addition, M has a mobile subscriber ISDN number (MSISDN) which is the number others dial to reach him.

When M enters the aircraft, if his mobile phone is switched on it will continuously monitor the broadcast control channel (BCCH) radiated by the BTS 33 and will make itself known to the ground-based system periodically (e.g. by default every 15 minutes or so). Essential details on M which the system requires to know are contained in his SIM (Subscriber Identity Module), a variety of smart card which must be inserted into the mobile phone if the latter is to function. These details include M's IMSI (unique subscriber identity) and his own secret key for authentication purposes and

these are sent via the BSS 31 and the TFTS 36 to the TFTS network 39, 40 and thence to the GMSC 70, VLR 71, AUC 72 and EIR 73, where they are used to update the system on M's activity and whereabouts. In particular, the secret key is used in conjunction with a random number in a special algorithm to generate an output number both in the mobile phone and in the AUC. A match between these output numbers authenticates the user. In addition, an equipment number peculiar to M's phone is sent to the EIR where it is checked against a list of such numbers and its status verified. If M's phone is not "black-listed", M's call is further authenticated.

M's IMSI is used by the GMSC to check the services and area restrictions to which M may be subject and, if the service in question and the area in which M finds himself are not restricted, this together with the authentications just described enable M to place and receive calls in the aircraft in that particular location.

M's location as noted by the VLR 71 is relayed back to M's own HLR 61 in order to update the records held there. This record then acts as a central routing pointer for outside callers wishing to contact M. The VLR in practice sends an MSRN (roaming number) back to the HLR which identifies that VLR as the one through which M can currently be reached.

If F now dials M's MSISDN number in an attempt to reach M, a message related to F's call will go via the ISDN system to the gateway MSC 53 which then routes it to M's own HLR (in this case the illustrated HLR 61). The specific HLR is identified by the MSISDN itself.

The HLR 61 sends back to the GMSC 53 the roaming number (MSRN) which is used by the GMSC 53 to route the call to the VLR 71. This VLR now converts the MSRN to M's own TMSI (Temporary Mobile Subscriber Identity) which is sent via the TFTS network to the aircraft, where M's phone is caused to ring by way of the BTS 33. Thus a link is established between F and M and voice communication may take place between them. Equally, if the terminal used by M allows this (e.g. if his phone has an LCD screen which can display short messages or his terminal is a radio laptop), alphanumeric or data messages may be exchanged. This assumes that M has subscribed to, for example, the Short Message Service which mobile operators offer.

In order to be able to route the call request to the correct aircraft, TFTS manages the location of the aircraft in an entity called the Gateway Location Register (GLR) 75. This may be either a single entity which serves all the various GSC's in the TFTS system, or there may be several in the system, depending on the level of traffic. This maintains information related to the best route to reach all aircraft currently connected to the TFTS network. The GLR 75 automatically updates this information as the aircraft flies through the network, the aircraft to this end being arranged to transmit "location registration" messages whenever the airborne TFTS 36 decides that it is appropriate to change cell.

If, conversely, M wishes to place a call to F on the ground, he dials F's ISDN number (the HLR-code part of the MSISDN is not needed in this case) and is linked to the aeronautical GMSC 70 via the particular TFTS GS 39 which is receiving his signal, and then from the GMSC 70 directly to F via the PSTN/ISDN system.

Where M wishes to call another mobile number, e.g. a subscriber M*, he dials M*'s MSISDN number and is routed, as in the last scenario, to the GMSC 70 which, analogous to the GMSC 53 in F's case, contacts F's own HLR and extracts therefrom F's latest MSRN (roaming number). The call is then routed through to M*'s current MSC and VLR, the latter then converting this MSRN into M*'s own TMSI (temporary subscriber number), this number being then used to page M* through his current BSC and BTS.

Finally, a call from, say, M* to M is achieved by M* dialling M's MSISDN number, upon which his call is routed via his current BTS, BSC and MSC (not a gateway MSC this time, since M* is already on the mobile network) to M's HLR 61 which passes back to M*'s current MSC M's current roaming number (MSRN). M* is thereby routed through to M's current VLR 71 which, again, converts that MSRN into M's current TMSI which is routed through the TFTS network to the GSM equipment onboard the aircraft, so that M is then paged.

The invention may even cater for calls made from one aircraft occupant to another occupant of the same aircraft, for example where the parties concerned are at opposite ends of the aircraft and/or where it is inconvenient for the calling party to leave his or her seat to visit the called party in person. For this reason, and other reasons relating to the efficiency of routing incoming calls, the invention also envisages the inclusion of some MSC functionality within the airborne equipment, i.e. linked with the BSS 31 onboard the aircraft.

It is a feature of the present invention that the power radiated by each individual onboard mobile phone can be reduced to a very low level while still enabling reliable communication to take place. Helpful in this regard is the possibility of using more than one antenna in the single cell defined by the BTS 33 to cover the whole passenger area of the aircraft. This has two benefits: firstly, radiations that do emanate from the individual mobiles are of a strength which is very unlikely to interfere with the proper operation of the measuring and communications systems of the aircraft itself.

A second advantage of the ability to reduce power in the mobile phones is the reduced interference with ground equipment. Since an aircraft overflies the GSM network of masts, it may have a direct line of sight with quite a number of them so that the onboard GSM equipment could conceivably communicate with more than one on a particular channel. This would have the effect of taking up capacity on the system, which is clearly wasteful. Reduction of power, however, serves to mitigate this problem.

If it is felt, nevertheless, that there is likely to be a problem with leaking radiation from the phones themselves, and/or from the internal antennas 35, the inventors propose the attachment of a transparent, attenuating, plastic film to the inside of each window in the passenger compartment. Self-adhesive film would be easiest to install and would also be relatively inexpensive.

Returning to the matter of the reduction of power in the mobiles, it is common practice in GSM to arrange for the BSC and the mobiles it serves to operate at the lowest power level that will maintain an acceptable signal quality, yet also minimize co-channel interference and save power. In this invention, as in normal GSM practice, the onboard

BSC 34 performs measurements on the power level on the different mobiles and adjusts their levels so that the power is approximately equal for each channel burst occupied by the respective mobiles, while at the same time minimising the overall power level as just mentioned.

In a particular realisation of the invention it is arranged for the BSC 34 to be able to shut the mobile phones off inside the aircraft.

A potential problem with the implementation of the invention is the fact that passengers may be carrying phones based on differing frequency standards. Thus, while the UK operators Cellnet and Vodaphone operate in the 900 MHz band, Orange and One-to-One in the UK operate in the 1800 MHz band and US networks commonly operate at 1900 MHz. In order to be able to accommodate these differences, the onboard BTS 33 is arranged to operate at more than one frequency, in particular 900 and 1800 MHz. These frequencies may be used either simultaneously or serially, depending on the economics involved. As regards unsupported mobiles, it is envisaged under the present invention that the frequencies of these phones will be monitored and, if power is detected on those frequencies either before takeoff or during flight, the crew will be alerted who will then request the passengers concerned to turn their mobiles off.

In the unlikely event that a mobile phone malfunctions and radiates an unacceptably high level of power, even during standby, the monitoring facility just mentioned will detect this and likewise alert the crew. Since the phones only radiate periodically on standby, so that they can perform the short logon "burst" necessary to

indicate their presence to the rest of the system, it is necessary that the monitoring facility be of the "staring" type, i.e. continuously active.

In summary, then, what has just been described is an embodiment of an invention which allows aircraft passengers to take on board their normal mobile phones and use them in the way they would normally do to communicate with ground-based parties. The numbers they would dial would be no different from the numbers that would normally be dialled for those parties (including the international prefix). Similarly, ground-based parties may freely dial up parties who are temporarily in flight, again without any special provisions having to be made in the form of special numbers, etc. Thus the invention provides a communication system in which a ground-based calling party need not know that the called party is in the air, similarly a passenger in flight can call someone without having to consider whether that person is on land or is himself also in the air.

While the described embodiment has been based on the use of certain specific features, in particular an onboard GSM microcell and a TFTS bearer system, in practice the invention is not limited to these, but instead other mobile communications systems may be used, and likewise other bearers. As examples, other possible mobile systems are NADC (North American Digital Cellular), DCS (Digital Cellular System) 1800, PDC (Personal Digital Cellular), JDC (Japanese Digital Cellular) and PCS (Personal Communications Systems), while alternative bearers are SATCOM, NATS (North American Terrestrial Service), IRIDIUM, etc. Different bearers will require different interfacing with the mobile system on board the aircraft, cf. the protocol converters 32

and 74 in the GSM/TFTS case, and will need the provision of the function of the aeronautical GMSC 70.

CLAIMS

1. An aircraft communications apparatus for establishing a communications link between a party on an aircraft and a party external to the aircraft, comprising a means for defining a radio-frequency microcell within the aircraft, the cell-defining means being functional, in use, in co-operation with a mobile station employed by said party on the aircraft.

2. Communications apparatus as claimed in Claim 1, wherein the cell-defining means is configured to operate under the same format as a ground mobile network system in association with which the mobile station is configured to operate.

3. Communications apparatus as claimed in Claim 1 or Claim 2, wherein the cell-defining means comprises a base station subsystem and one or more antennas connected to the base station subsystem.

4. Communications apparatus as claimed in Claim 3, wherein the one or more antennas are distributed around an interior space of the aircraft.

5. Communications apparatus as claimed in Claim 3 or Claim 4, comprising a bearer transceiver means connected to the base station subsystem for the establishing of said link.

6. Communications apparatus as claimed in Claim 5, comprising a protocol-conversion means interconnecting the base station subsystem and the bearer transceiver means.

7. Communications apparatus as claimed in any one of Claims 3 to 6, wherein the base station subsystem comprises a base station controller and a base station transceiver.

8. Communications apparatus as claimed in any one of Claims 3 to 7, wherein the base station subsystem is operable at more than one broadcast frequency.

9. Communications apparatus as claimed in any one of the preceding claims, comprising a power monitor connected to the defining means for the monitoring of the level of power radiated by the mobile stations and for the switching off of the mobile stations when the level exceeds a given value.

10. Communications apparatus as claimed in any one of the preceding claims, wherein the cell-defining means is a GSM cell-defining means.

11. Communications apparatus as claimed in any one of the preceding claims, wherein the bearer transceiver means is one of a group comprising a TFTS, a SATCOM, a NATS and an IRIDIUM bearer transceiver means.

12. A communications apparatus as claimed in any one of Claims 1 to 9, comprising an aeronautical gateway switching device for the interfacing of signals from the cell-defining means with a mobile communications network and/or a public switched telephone network and/or an integrated services digital network.

13. Communications apparatus as claimed in Claim 12, wherein the aeronautical gateway switching device interfaces said signals by way of a ground-based bearer apparatus which, in use, communicates with the on-board bearer transceiver means.

14. Communications apparatus as claimed in Claim 13, comprising a further protocol conversion means for the interfacing of the gateway switching device with the ground-based bearer apparatus.

15. Communications apparatus as claimed in Claim 13 or Claim 14, wherein the cell-defining means and the mobile communications network are a GSM cell-defining means and a GSM mobile communications network, respectively.

16. Communications apparatus as claimed in any one of Claims 13 to 15, wherein the onboard bearer transceiver means and the ground-based bearer apparatus are a TFTS bearer transceiver means and a TFTS ground-based bearer apparatus, respectively.

17. A communications arrangement for the establishing of a communications link between an occupant of an aircraft and another party, comprising:

- in an aircraft, a microcell-defining means configured in accordance with a given mobile-communications format for co-operation with one or more onboard mobile terminals likewise configured to operate under the given format, and a first bearer means connected to the cell-defining means for establishing a communications link with ground, and

- on the ground, a second bearer means for communicating with the first bearer means, a mobile-communications network configured according to the given format, and a gateway switching device connected to interface the second bearer means with the mobile-communications network and with a public switched telephone network and/or an integrated services digital network.

18. Communications arrangement as claimed in Claim 17, wherein the mobile-communications format is GSM.

19. Communications arrangement as claimed in Claim 17 or Claim 18, wherein the first and second bearer means are one of a group comprising a TFTS, a SATCOM, a NATS and an IRIDIUM bearer means.

20. Communications arrangement as shown in, or as hereinbefore described with reference to, Figure 3 of the drawings.